Total Internal Reflection

Read from **Lesson 3** of the **Refraction and Lenses chapter** at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/refrn/u14l3a.html
http://www.physicsclassroom.com/Class/refrn/u14l3b.html
http://www.physicsclassroom.com/Class/refrn/u14l3c.html

MOP Connection: Refraction and Lenses: sublevels 5 and 6

Background:

Whenever a light ray reaches the boundary with a transparent medium, a portion of the light energy is transmitted across the boundary and appears as a refracted ray; and a portion of the energy remains within the original medium and appears as a reflected ray. The path of the refracted ray follows **Snell's law**. The path of the reflected ray follows the **law of reflection**. The amount of light energy that is reflected and transmitted is dependent upon the angle of incidence. At certain angles, all of the light is reflected (none is transmitted) and remains inside the original medium. This is known as total internal reflection (TIR).

1. Light will undergo total internal reflection only when it is _____. Choose two.
   a. in the less dense medium traveling towards the more dense medium
   b. in the more dense medium traveling towards the less dense medium
   c. in the medium where it travels slowest, moving towards the medium where it travels fastest
   d. in the medium where it travels fastest, moving towards the medium where it travels slowest

2. Total internal reflection is most likely to occur when _____.
   a. the angles of incidence are smaller (e.g., close to 0 degrees)
   b. the angles of incidence are greatest (e.g., close to 90 degrees)

Complete the following blanks by answering questions #3-#4:

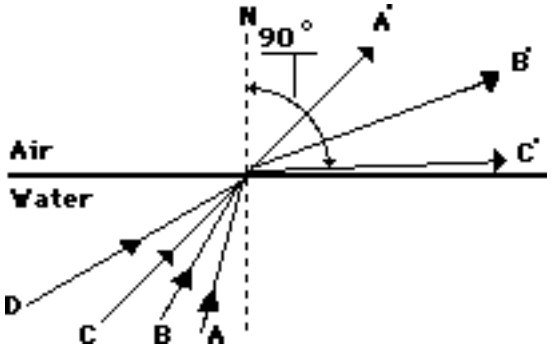
The critical angle is the angle of _____(#3)_____ that causes light to _____(#4)_____.

3. Referring to the statement above:
   a. incidence b. refraction c. reflection

4. Referring to the statement above:
   a. cross the boundary without refracting
   b. undergo refraction at the same angle as the angle of incidence
   c. refract at an angle of refraction of 90 degrees
   d. reflect at the same angle as the angle of incidence

The next three questions focus on the brightness of the reflected and refracted rays and the dependency of the brightness upon the angle of incidence.

5. Consider the diagram at the right for rays **A**, **B**, **C**, and **D** incident upon a water-air boundary. The corresponding refracted rays are shown. Draw the corresponding reflected rays and label them as **A"**, **B"**, **C",** and **D"**.



6. As the angle of incidence is gradually increased, more and more of the energy from the incident ray goes into the reflected ray, while less and less of the energy goes into the **refracted** ray. Based on this fact, which one of the refracted rays in the diagram would be brightest and which one would be dimmest?

Brightest: _____ **Dimmest**: _____

7. For incident ray **C**, the angle of refraction is 90°. The refracted ray C has the smallest amount of energy of any refracted ray. Thus, it would be an extremely "dim" light ray. What is the angle of incidence for ray **C** called?

8. The critical angle for an air (n=1.0) - Lucite (n=1.4) boundary is approximately 46 degrees. Which of the following diagrams depict incident rays that would undergo total internal reflection (TIR) at the angle shown? Circle all that apply.

Diagram A

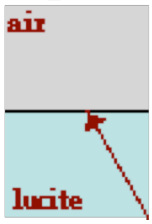


Diagram B

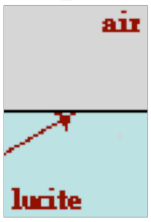


Diagram C

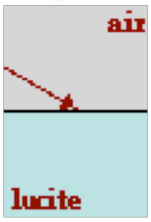
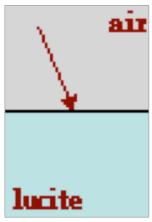


Diagram D



9. Calculate the critical angle for the ....
   a. ... air (n = 1.00) - water (n = 1.33) boundary:

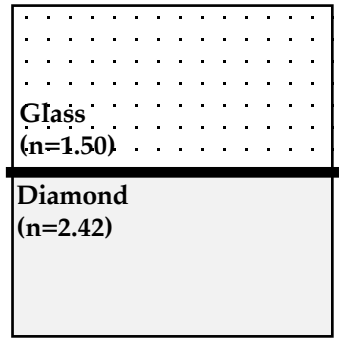
   b. ... air (n = 1.00) - diamond (n = 2.42) boundary:

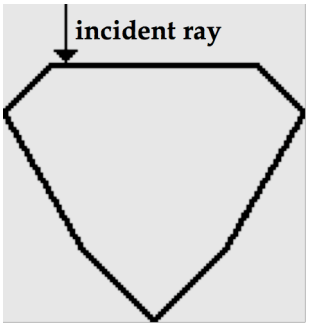
   c. ... water (n = 1.33) - glass (n = 1.50) boundary:

10. a. Calculate the critical angle for the boundary between glass (n = 1.50) and diamond (n = 2.42). **PSYW**

    b. On the diagram at the right, draw an incident ray that approaches the boundary with an angle equal to the critical angle. Label the incident ray as **A**. Draw the corresponding refracted ray and label the ray as **B**.

    c. Draw an incident ray that would approach the boundary at an angle greater than the critical angle. Label this incident ray as **C**.





11. Diamonds are usually cut with a shape similar to that shown at the right. Kent Affordit is preparing to propose to Amanda Befrendswyth. In an effort to save money, Kent asked the jeweler to remove the bottom portion of the gem. Kent reasoned that since it was not visible, its removal would have little consequence to its ultimate appearance. Explain why Kent never did get engaged to Amanda. Finally, draw the path of the given incident ray in each diamond.